MONTHLY PROGRESS REPORT

"HTS Josephson Technology on Silicon with Application to High Speed Digital Microelectronics"

Contract No: N00014-94-C-0261
Office of Naval Research, Arlington, VA
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Report No.: (0001AE)

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Summary of Progress

Task 1: Josephson junction fabrication and Testing

The highlight of this month's technical progress was the fabrication of working Josephson junctions and a SQUID using YBCO films grown on YSZ buffered silicon.

Two SQUID's were fabricated. SQUID R1 did not exhibit any magnetic field modulation, although the shape of the current-voltage (IV) characteristic was RSJ-like. This SQUID exhibited clear microwave induced Shapiro steps in the IV curve. Fig. 1 shows the dc IV curve of this SQUID. Fig. 2 shows Shapiro steps in the IV curve of SQUID R1 (at 54 K) as induced by a 10.2 GHz microwave source. This SQUID had a resistance of approximately 0.4 Ω.

SQUID R1 was fabricated by e-beam modification using a beam dwell time of 600 ms. and 2048 dwell points. These conditions usually give T_c of ~50 K, but in this case, T_c for the SQUID was ~61 K. This is probably due to inhomogeneity in the film, which could result in significantly different critical temperatures between the two junctions of the SQUID. If one of the junctions was completely non-superconducting, then we would expect the structure to display the observed behavior.

SQUID R2 showed both SQUID-like magnetic interference and microwave induced steps in the IV curve. Fig. 3 shows an SEM image of this SQUID. Fig. 4 shows the dc IV curve for this device at a temperature of 40 K. Fig. 5 shows the IV curve under the influence of 10.2 GHz microwaves. Note the existance of pronounced Shapiro steps.

Fig. 6 shows the magnetic interference pattern of SQUID R2.

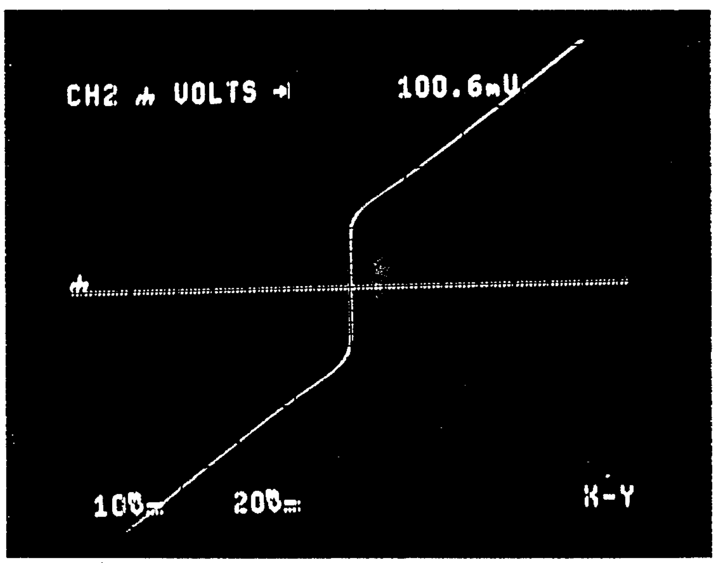

Fig. 1. Current-Voltage characteristic of SQUID R1 at a temperature of 61 K.

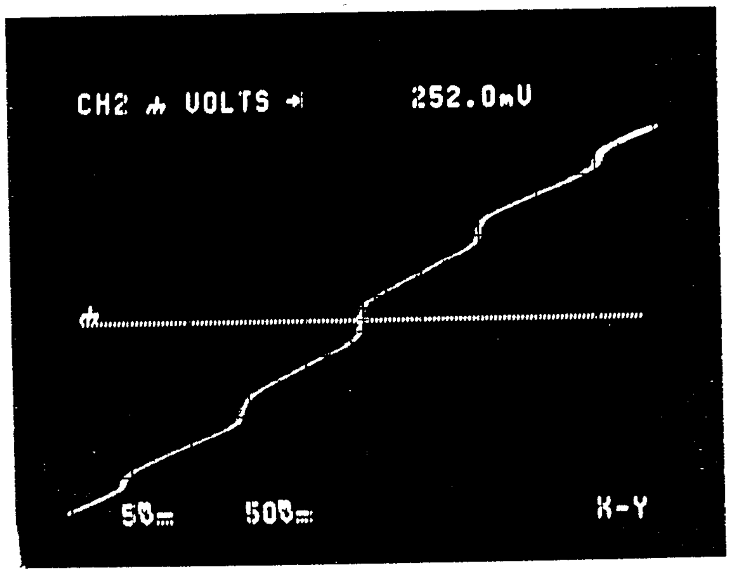

Fig. 2. Microwave induced steps in the current voltage characteristic of SQUID R1 at a temperature of 54 K.

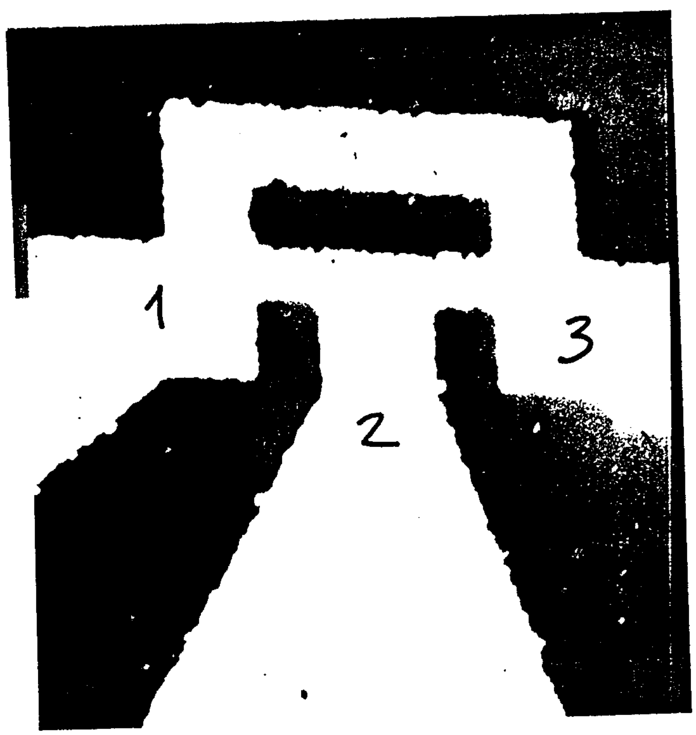

Fig. 3. SEM micrograph of SQUID R2.

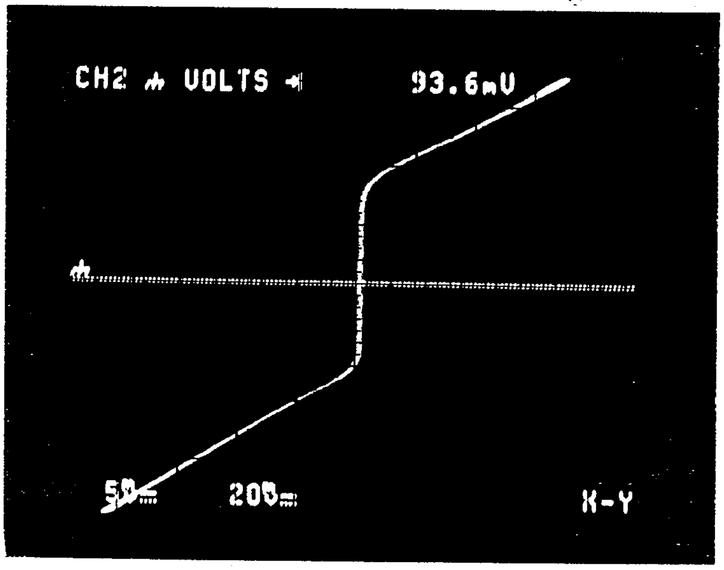

Fig. 4 DC IV curve of SQUID R2 at a temperature of 40 K.

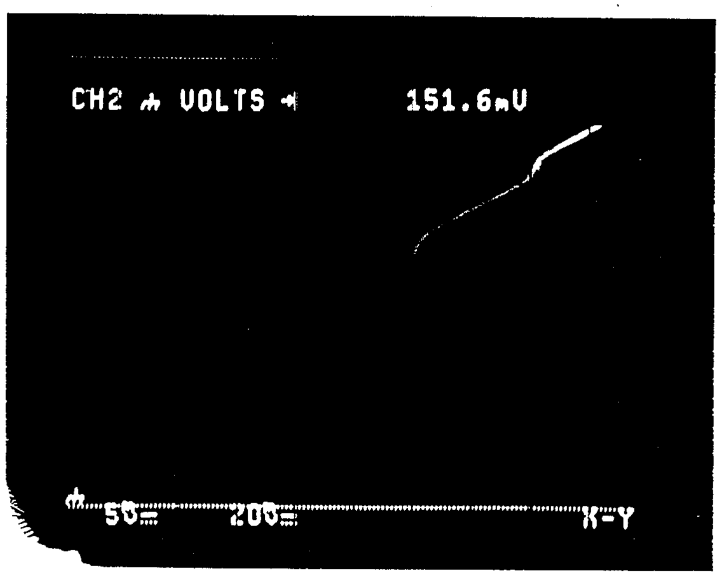

Fig. 5 IV curve of SQUID R2 at T = 39 K, under the influence of 10.2 GHz microwaves.

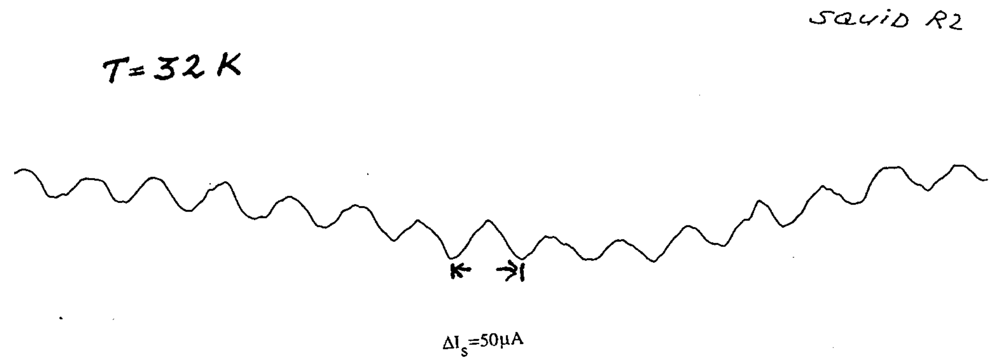

Fig. 6 Magnetic interference pattern of SQUID R2 at 32 K.

Task 2: RSFQ Modeling and Design

SQUID R2 exhibited magnetic modulation of the critical current only at temperatures at least 7 K below the critical temperature of the SQUID. This suggests that one of the junctions had a higher T_c of 45 K, and the other had a T_c around 37 K. The magnetic modulation was measured by injecting current across the SQUID loop, between terminals one and three as shown in Fig. 3. For this geometry, the inductance is given by $L= \varphi 0/\Delta I_S$, where ΔI_S is current amplitude associated with one oscillation of the SQUID. From the measurement shown in Fig. 6, we infer that the inductance is approximately 40 pH. This value is approximately a factor of two higher than is typically seen with SQUIDs fabricated on conventional i.e. $LaAlO_3$ substrates. This difference in inductance is likely due to parasitic kinetic inductance associated either an increased magnetic penetration depth, or possible to microstructural defects in the film used for the SQUID.

We will attempt to improve the quality of our films and get more data to get a better assessment of the role of film quality on SQUID inductance. It is important to resolve this issue before undertaking a serious effort to fabricate a more complicated RSFQ logic element.

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